State-of-the-Art in Life Cycle Sustainability Assessment (LCSA)

Life Cycle Sustainability Assessment of Products*#

(with Comments by Helias A. Udo de Haes, p. 95)

Walter Kloepffer

LCA Consult & Review, Am Dachsberg 56E, 60435 Frankfurt/M, Germany (walter.kloepffer@t-online.de)

DOI: http://dx.doi.org/10.1065/lca2008.02.376

Please cite this paper as: Kloepffer W (2008): Life Cycle Sustainability Assessment of Products (with Comments by Helias A. Udo de Haes, p. 95). Int J LCA 13 (2) 89–95

Abstract

Background, Aims and Scope. Sustainability was adopted by UNEP in Rio de Janeiro (1992) as the main political goal for the future development of humankind. It should also be the ultimate aim of product development. According to the well known interpretation of the original definition given in the Brundtland report, sustainability comprises three components: environment, economy and social aspects. These components or 'pillars' of sustainability have to be properly assessed and balanced if a new product is to be designed or an existing one is to be improved.

Methods. The responsibility of the researchers involved in the assessment is to provide appropriate and reliable instruments. For the environmental part there is already an internationally standardized tool: Life Cycle Assessment (LCA). Life Cycle Costing (LCC) is the logical counterpart of LCA for the economic assessment. LCC surpasses the purely economic cost calculation by taking into account the use- and end-of-life phases and hidden costs. For this component, a guideline is being developed by SETAC as a basis for future standardization. It is a very important point that different life-cycle based methods (including Social Life Cycle Assessment 'SLCA') for sustainability assessment use consistent – ideally identical – system boundaries. This requirement includes that in LCC the physical life cycle ('from cradle-to-grave') is used instead of the frequently used marketing life cycle ('from product development-to-end of market life').

Future Developments. SLCA has been neglected in the past, but is now beginning to be developed. The central problems seem to be how to relate the social indicators (social impact assessment) to the functional unit of the product-system and how to restrict the many social indicators proposed to a manageable number. Meanwhile, qualitative and semi-quantitative approaches are used as substitutes for a full, quantitative SLCA. It is hoped that new methods will be developed and finally standardized by ISO. The combination of LCA, LCC and SLCA will provide the much needed tool for sustainability assessment of products.

Keywords: Life cycle costing (LCC); life cycle sustainability assessment (LCSA); products, life cycle sustainability assessment; sustainability; sustainable products

Introduction

The term 'sustainability' is much used, and sometimes misused, in the political discussion concerning global development and the environment. This paper deals with a proposition how to quantify sustainability, restricted to the assessment of products (goods and services). It does not treat any problems which may be connected with the sustainability in large political or macroeconomic systems. The sustainability of production sites, or firms for that matter, is also not the focus of this short treatise. This is in line with the original definition and use of LCA as an essentially comparative method of environmental **product** assessment.

It was the result of a discussion at the first SETAC Europe LCA Symposium in Leiden (December 1991) that LCA is synonymous with **environmental** Life Cycle Assessment. It was clear from the beginning that a full sustainability assessment would require at least two further dimensions, the economic and the social ones. This problem finally surfaced, approximately ten years and two UN world conferences (Rio de Janeiro and Johannesburg) later, and we, therefore, must consider to complementing our 'good old LCA'.

Before trying to operationalize sustainability, we have to ask for the exact meaning of the term. In the German-speaking countries there is a strong inclination toward the forests and, hence, the definition of 'Nachhaltigkeit'[1] began with the good practice of cultivating forests. The most influential pioneering book in this field – 'Sylvicultura Oeconomica' – by Hans-Carl von Carlowitz was published in Leipzig 1713 [1]. Carlowitz was not a forester, however, but the superintendent of the Saxonian silver mines. In this position, he needed and used quite a bit of timber and remarked that the forests in Germany were in a very bad shape at that time. Forestry was the life-long hobby by Carlowitz and he found the basic law of sylviculture, i.e. that not more wood should be removed from the forests as can grow in the long run[2]. He even recognized the relationship of environmental – as we would say today – economic and social factors. Although the book is no easy reading – it is written in a baroque German and printed in gothic letters – its message is clear and very relevant for our discussion.

In modern times, 'Sustainability' became known as a term related to global development:

> Sustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs.

This famous definition of 'sustainable development' in the Brundtland report [2] stresses the responsibility humankind

* **ESS-Submission Editor:** Dr. David Hunkeler (david.hunkeler@aquaplustech.ch)

Presented at the 3rd International Conference on Life Cycle Management in Zurich, August 2007.

[1] German word for 'sustainability'

[2] This sound trivial today, but the same is true for the great physical laws of conservation of mass and energy, detected later.

has toward the future generations. Although this high claim is not easy to operationalize (perhaps exactly for that reason?), it has been very successful in the field of politics.

The United Nations declared sustainability as the guiding principle for the 21st Century in Rio de Janeiro 1992. The confirmation, ten years later in Johannesburg, even introduced the life cycle aspect, perhaps not LCA in the narrow sense, but life cycle thinking, and life cycle management (LCM). Despite all successes in the political arena, there remains the need for quantification or operationalization of sustainability in order to avoid wrong product claims[3].

It is the purpose of this paper to summarize the state of the art in Life Cycle Sustainability Assessment (LCSA, see section Introduction) and to propose a unified set of methods which are qualified to be standardized and will serve to assess the sustainability of product systems in the near future. The emphasis of the approach is on feasibility and robustness rather than scientific brilliance and completeness. There is also the aspect of time: the global situation is worsening at such a pace that we cannot wait until science will have studied all details of possible future developments, a state which will never be reached and is even unthinkable to most of us. The approach should be flexible enough, however, to include new scientific and technological developments.

1 The Three Pillar Model

The standard model, which is well accepted by industry and often called the 'triple bottom line', is the 'three pillar' interpretation of sustainability [5,25,38][4]. It says essentially that for achieving (or assessing) sustainability, the environmental, economic and social aspects have to be tuned and checked against each another.

It has already been mentioned that this interpretation was already known and discussed at the first SETAC Europe LCA symposium 1991, but it is older. The first use of three dimensions known to the author was a method called 'Produktlinienanalyse' by Oeko-Institut in Germany 1987 [3] – the same year in which the Brundtland Report appeared in print [2]. This 'Product Line Analysis' (today extended to a LCM 'Product Portfolio Analysis' – PROSA [4]) was a 'proto-LCA'[5] including an impact assessment with three instead of one dimensions. The three pillar interpretation is, thus, neither new, nor an invention by industry.

Given the widespread acceptance of the model [25], it is rather straightforward to propose the following scheme for **L**ife **C**ycle **S**ustainability **A**ssessment (LCSA)[6] [6]:

LCSA = LCA + LCC + SLCA

where LCA is the SETAC/ISO environmental Life Cycle Assessment, LCC is an LCA-type ('environmental') Life Cycle Costing assessment and SLCA stands for societal or social Life Cycle Assessment.

There are, however, some prerequisites for using this scheme. The most important requirement is that the system boundaries of the three assessments are consistent (ideally identical). This includes, of course, that in LCC the physical (as opposed to the marketing)[7] life cycle is used for modelling the Life Cycle Inventory (LCI). The best solution would be the use of one identical LCI for all three components. It seems, however, that the societal LCI will be much more demanding with regard to regional resolution than LCA and LCC. The reasons the methods have to be life-cycle based is easy to explain and, indeed, involve the same arguments as for LCA, i.e. recognising and avoiding trade-offs by including the whole life cycle ('cradle-to-grave'). With regard to sustainability, avoiding the shifting of problems into the future is of special importance, due to the request for intergeneration fairness [2].

2 Status of Development

2.1 (Environmental) life cycle assessment, LCA

LCA is the only internationally standardized environmental assessment method. The two most important features of LCA are the analysis from 'cradle-to grave' and the use of a functional unit for comparative studies. The international standards have been slightly revised and ISO 14040+44 (10/2006) superseded the old series ISO 14040 to 43 (1997–2000). The well known structure of Goal definition and scoping, Inventory analysis, Impact assessment and Interpretation was developed during the harmonisation/standardisation work by SETAC and ISO. Out of experience, strong hurdles against misuse of the method were built into the standards, especially if comparative assertions are made and are intended to be made public. Thus, the standardization of LCA has reached a mature stage and further progress is expected to proceed more slowly than 10 to 15 years ago. On the other hand, it is well known that LCA is still an active field of research so that further methodological developments are to be expected. To mention just a few: the definition of difficult impact categories, I/O- and hybrid analysis, consequential LCA, and the proper use of LCA in Life Cycle Management.

As with all assessment methods, there are also some limitations in LCA, e.g. the great difficulty to include elements of risk assessment[8]. The most important limitation, however, seems to be the need that all impacts have to be related quantitatively to a functional unit; qualitative marks ('flags') are mostly lost during the assessment work [31]. Thus, one of the most important environmental impacts, the loss of biodiversity, cannot be directly quantified in Life Cycle Im-

[3] Comparative assertions of the kind 'product A is more or equally sustainable than product B', see the similar discussion in the LCA standard ISO 14040.

[4] See also the logo of this journal; the term 'Triple Bottom Line' has been coined by John Elkington [38].

[5] 'Proto-LCA' designates an early LCA, LCI or ecobalance before the harmonisation by SETAC and standardisation by ISO started in the 1990s, i.e. from about 1970 to 1990 [22].

[6] I thank Isa Renner and Matthias Finkbeiner for pointing out that the notation SustAss formerly used [6] should better be replaced by LCSA for the sake of clarity.

[7] The marketing life cycle extends from product development, introduction into the market until the end of the market life (i.e. end of production and sale).

[8] It seems that there are two worlds of environmental assessment: the world of hazard (i.e. potential impacts) and the world of risk (i.e. real impacts x probability of occurrence), LCA clearly belonging to the world of hazard.

pact Assessment (LCIA), although the impact category 'Land Use' may be used to indirectly assess biodiversity [32]. The lack of regional and temporal specification inherent to LCA may also be seen as a draw-back, but in this case great efforts have been made to overcome this deficiency [33], albeit at the price of higher data demand and loss of simplicity. The need for higher regional resolution in SLCA (see section 1.3) may in the future help to improve the environmental Life Cycle Inventories, too. The old conflict [34] between feasibility and simplicity (precautionary principle, 'less is better') on the one hand, and realistic modelling of impacts in LCIA on the other, seems to go into a new round.

2.2 Life cycle costing, LCC

Environmental (or LCA-type) Life Cycle Costing (LCC) summarizes all costs associated with the life cycle of a product that are directly covered by one or more of the actors in that life cycle (e.g., supplier, producer, user/consumer and those involved at the End-of-Life); these costs must relate to real money flows in order to avoid overlap between environmental LCA and LCC[9]. Environmental LCC is performed on a basis analogous to LCA, with both being steady-state in nature. This includes the definition of a functional unit and similar system boundaries in both LCA and LCC. Ideally, an LCA or LCI should be available for the same product system(s), but a LCC can also be performed as a stand alone assessment.

LCC is older than LCA, though is not yet standardized, except for very special purposes. A SETAC Europe working group on LCC prepared a manuscript for publication by SETAC [7]. In this book the different types of LCC are described and defined. For use in LCSA, only the 'environmental', i.e. LCA-compatible, LCC as defined above is suitable. A short **LCC guideline** focussing on this type of LCC, about the size of the Sesimbra Code of Practice (1993) [8], is being distilled out of the book [7] and enriched by some new elements. This document will be ready at the 5th SETAC World Congress in Sidney, August 2008, for a final round of discussion. This 'environmental' LCC is shaped according to the structure of LCA, as defined in ISO 14040. It includes the whole physical life cycle of a product with the use- and end-of-life phases and avoids any monetization of external costs, which may occur in the future due to environmental damages in order to avoid double counting. Environmental impacts are dealt with as part of LCA (Life cycle impact assessment, LCIA) in physical – as opposed to monetary – terms. Costs occurring in the future, e.g. due to climate change or radioactive waste are difficult, if not impossible to estimate. External costs to be expected in the decision-relevant near future, however, comprise real money flows as well and must be included.

In contrast to LCA, LCC has no component Impact Assessment. The aggregated result is a calculated cost per functional unit expressed in one of the well known currencies. It is tempting to use the price of a product as the 'zeroth approximation' of the aggregated result, since also the price contains implicitly the costs of the raw materials, intermediates etc. It does contain in addition, however, the profit margins, but not the costs incurred in the use and end-of-life (EOL) phases of a product. These may outweigh the costs of procurement, especially if the use phase includes heavy energy use and/or significant maintenance costs. The EOL costs may be included in the price in exceptional cases, e.g. the German 'green dot' system of packaging recycling.

As in LCA, the detailed analysis of the life cycle phases should not be lost during aggregation. Only in that way, opportunities for cost reductions can be fully recognized. This is especially important for 'green' products (including services!) which often are more expensive than the traditional competing products (e.g. energy saving vs. traditional bulbs). That such products are cheaper over the entire life cycle is generally ignored by consumers.

LCA-compatible or 'environmental' LCC is also different from traditional economic accounting, even if in the more recent 'Environmental Management Accounting' life cycle aspects are incorporated [23]. The two fields of environmental accounting and LCC should learn from each other, however [24].

To sum up, LCC is a useful complement to LCA (and SLCA), since sustainable products should be profitable and not unreasonable expensive – otherwise they will not be accepted at the market. Since decisions by consumers are often based solely on the price of a product, information as given by LCC (including the use phase) may lead to better decisions encompassing the needs of future generations. These considerations show that LCC is useful also as stand-alone assessment which may later be complemented by an LCA and/or a SLCA. This may require a change of the Goal & Scope.

2.3 Societal life cycle assessment, SLCA

Societal LCA, the third pillar of LCSA, is generally considered to be still in its infancy, although the idea is not new [3,9]. Despite the great methodological difficulties, however, an astonishing increase in papers submitted and published can be observed. Without going into details, the most recent papers can be summarized as follows:

- Dreyer et al. [10] aim at assessing the responsibility of the companies involved in the life cycle, although the products are the point of reference. This necessarily gives more weight to the foreground activities and to the people involved in it. The responsibility of the management for the social conditions in a plant cannot be debated and this may be more important than the processes used. On the other hand, the same is true for the machinery and the environmental technology used (or not used).
- Weidema [12] includes elements of Cost Benefit Analysis (CBA) and proposes Quality Adjusted Life Years (QALY) as a main measure of human health and well-being (a common endpoint for toxic and social health impacts)
- Norris [13] also considers social and socio-economic impacts leading to bad health; Life Cycle Attribute As-

[9] Such an overlap would occur if environmental damages were monetized in LCC.

sessment (LCAA) as a web-based instrument should complement classical life cycle assessment methods.
- Labuschagne and Brent [11] strive for completeness of the indicators. The method seems, however, not primarily directed versus product assessment.
- Hunkeler [14] solved the problem of relating societal impacts with the functional unit by means of the working time spent to produce the fraction of the final product in a factory or at the field etc. This time has to be determined as part of the societal LCI; this can be done, but it has to be known **where** the work is done. Regionalisation has to be more developed than usual in LCI/LCA. Knowing the working hours per functional unit and using national statistics it can be calculated how many hours a person has to work for eating, housing, education etc. This evaluation can be considered as a societal impact assessment, whereas the unweighed working hours belong to the inventory.

Several other recently developed SLCA methods are rooted in eco-efficiency analysis, a combination of simplified LCAs and LCCs (approximated by the price). Saling et al. [15], e.g., added a social component to the BASF eco-efficiency analysis [16-18] called SEEbalance®. The two-dimensional eco-efficiency diagrams are thus enlarged to a cube which shows the position of a product according to all three pillars of sustainability. Since the method depends on weighing factors it should be used for internal purposes only.

A social assessment is also offered with the GaBi LCA software [19,26] and Alcan has recently patented a qualitative tool ASSET™ (Alcan Sustainability Stewardship Evaluation Tool) [39]. Grießhammer et al. [20] prepared a feasibility study for the UNEP-SETAC Life Cycle Initiative about the integration of social aspects into LCA. Since many social indicators cannot be quantified, qualitative ranking and scoring is used in addition to quantitative figures. Manhart [27] investigated the social impacts related to the production of notebooks.

Pesonen has also, very recently, advocated a simplified form of SLCA in the form of Sustainability SWOTs[10] [28], elaborated in expert sessions as a rapid tool for decision making. Benoît and Revéret [29] developed a method for SLCA and applied it in a case study about tomato cultivating in North America.

Finkbeiner [21] applied quantitative models (Human development index, Gini distribution index) and the criterion UN Global Compact to advance the SLCA methodology beyond the use of simple indicators. The big problem of impact assessment in SLCA, which does not exist in this form in LCA (in environmental assessment we know what is good and bad, at least we think so), is the scaling of some indicators, e.g. the payment of the workers: macro-economically, cheap labour may be a great advantage for developing countries in order to succeed in a global market. But where is the borderline to (overt or disguised) slavery? According to Hunkeler [14], the number of labour hours spent per functional unit (and region) is the central inventory item to be collected for the whole product tree. To do so, a better regional resolution will be necessary in order to locate the unit processes. It is important to note that the inventory data per se are neither good nor bad: to spend more labour hours per functional unit (e.g. using an obsolete process) is not socially advantageous. The social indicator in this method consists in calculating how many hours a person has to work in order to earn one unit of, e.g. health care, education etc. If this number is high, the average worker is poor and this correlates quantitatively to a total societal load per functional unit.

What is needed for this indicator is information which can deduced from national or international statistics and information provided from producers (labour hours per unit process) and other economic/technical data. Where detailed data are missing, generic (region-specific) averages will be used, as in the case of LCIA. Typical human rights indicators, e.g. the ban of child work, cannot be treated directly with this method, but societal impact assessment will consist of several impact categories, as in LCIA.

To conclude this review, Jørgensen et al. [30] reviewed most of the current SLCA literature, published papers and also less available grey literature. There is quite a bit of grey literature in this field, and the situation reminds one of LCA in the early 1990s. It is clearly too early for a standardisation of SLCA, though a certain level of harmonisation could be achieved if the different approaches were compared in case studies. It could also be quite useful, as in finance, to have different indicators measuring various aspects of SLCA. In that way, experience could be gained and the most suitable method(s) would emerge out of the ones proposed so far. With regard to the impacts and indicators it should be remembered that for good reasons there is also no definite list in LCIA (former ISO 14042, now part of 14044) either!

The main problems in SLCA seem to be the following:
- How to relate quantitatively the existing indicators to the functional unit of the system
- How to obtain specific data for the (necessarily) regionalized SLCA
- How to decide between many indicators (most of them qualitative) or a few ones that can be quantified, e.g. via the LCI labour hours per functional unit (Hunkeler [14])
- How to quantify all impacts properly
- How to valuate the results (see the example of very low payment)

The quantification of the indicators may be the most difficult problem and, indeed, the quantification of all environmental impacts in LCA has not been possible either. As an example, it should be recalled that he most important impact category in LCIA (biodiversity)[11] has no suitable indicator!

[10] SWOT stands for Strengths, Weaknesses, Opportunities and Threats (analysis).

[11] Biodiversity is sometimes seen as a safeguard subject or area of protection, see the 'Area of Protection Debate' DOI: http://www.scientificjournals.com/db/PDF/ehs/2002.03.014.pdf.

3 One Life Cycle Assessment or Three?

There are at least two options how to include LCC and SLCA in the sustainability assessment of products (LCSA):

Option 1:

LCSA = LCA + LCC + SLCA

Option 1 is based on three separate life cycle assessments with consistent, ideally identical system boundaries, as proposed in section 2. In the future, the three methods should be standardized (as LCA is already) or at least harmonized (SETAC Guideline for LCC in progress).

A formal weighting between the three pillars **shall not** be performed. The main advantage of this approach is its transparency – no meaningless sustainability points; the attribution of advantages and disadvantages in comparative assessments is clear, there is no (and shall never be) any compensation between the pillars.

Option 2:

LCSA = 'LCA new' (including LCC and SLCA as additional impact categories in Life Cycle Impact Assessment – LCIA)

Option 2 would mean that one LCI is to be followed by up to three impact assessments[12], possibly leading to the same set of areas of protection. The advantage of option 2 is that there is only **one LCI** model which has to be defined in the 'Goal and Scoping' component**.** On the other hand, Hunkeler also uses an environmental LCI in SLCA (14).

In the LCA/LCM community there are partisans of both options and the possible further extension of the ISO 14040ff series or a new international eco-efficiency standard[13] play an essential role in the discussion. An important question, therefore, has to be answered: is Option 2 compatible with ISO 14040? This standard (2006) says in the Introduction that

LCA addresses the environmental aspects and potential impacts, etc. and that

LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies described in this International Standard may be applied to these other aspects.

This favours clearly option one and a separate standardization of the LCA-type LCC and SLCA would be the logical consequence. On the other hand, of course, ISO 14040 and 14044 could be revised in the future again in order to comply with option 2. This would mean that the already now long standard ISO 14044 would be increased further by including the detailed 'shalls' necessary for LCC and SLCA. Also a 'new' ISO eco-efficiency standard would not invent LCA a second time, but only give advice how to use and combine it correctly with economic and social aspects for internal applications in industry. A detailed guidance, how to perform a LCC and/or SLCA would be needed in that case, too.

[12] Although LCC has no formal impact assessment.

[13] Lead country Sweden; first session December 3, 2007 in Göteborg.

4 Conclusions

If it is agreed that humankind has no chance to survive on this planet (and, thus, nowhere else), unless a sustainable development is achieved, sustainability has to be established at all levels. This includes the national, regional and global spheres, and, perhaps paramount, in communities. The proposition made here focuses to the relative modest aspect of products, including processes. Life cycle management is primarily carried out by industry and can be influenced by informed consumers. Progress can be made, step by step, without direct political influence (which, by its consensus nature is often too slow), but not without the economy. This is a strong argument for including LCC. Firms still carry out the majority of LCMs, and products have the impacts, though the effects are felt locally and globally (i.e. outside the site or corporate system). The shift in accounting for items outside the control of a multinational, and ensuring that local community based indicators show trends towards sustainability, is the greatest challenge in this field. Since **no development can be stable at the long run without social justice**, SLCA has also to be developed and considered.

It is often said that life cycle thinking is the core element of LCM and that the assessment methods used should be simple and not always quantitative ('tool box', for a survey see [37]). This may be true for finding hot spots, but certainly not for decision making: if different solutions are proposed, quantitative methods are needed[14]. It is the strength of LCA that quantification is possible and this advantage should be preserved in adding the economic and social aspects. This will be relatively easy for LCC, but difficult for SLCA. Given the great importance of the goal, equally great efforts should be made to provide and constantly improve the necessary assessment tools.

[14] This does, of course, not exclude the use of additional information from studies not using the life cycle approach (e.g. risk assessment), qualitative knowledge and intuition.

References

[1] Carlowitz HC (2000): Sylvicultura Oeconomica – Naturmäßige Anweisung zur Wilden Baum-Zucht. Leipzig 1713 (Reprint [ISBN 3-86012-115-4]: TU, Bergakademie Freiberg, Akademische Buchhandlung Freiberg 2000)

[2] WCED – World Commission on Environment and Development (1987): Our Common Future. Oxford

[3] Projektgruppe ökologische Wirtschaft (ed) (1987): Produktlinienanalyse: Bedürfnisse, Produkte und ihre Folgen. Kölner Volksblattverlag, Köln

[4] Grießhammer R, Buchert M, Gensch C-O, Hochfeld C, Manhart A, Reisch L, Rüdenauer I: PROSA – Product Sustainability Assessment. Öko-Institut e.V., Freiburg (undated)

[5] Hunkeler D, Rebitzer G (2005): The Future of Life Cycle Assessment. Int J LCA 10, 305–308

[6] Kloepffer W (2003): Life-Cycle Based Methods for Sustainable Product Development. Editorial for the Life Cycle Management (LCM) Section in Int J LCA 8, 157–159

[7] Hunkeler D, Lichtenvort K, Rebitzer G (eds): Environmental Life Cycle Costing. Report by a SETAC Europe working group, Taylor and Francis, Boca Raton, FL, USA (in print)
[8] Society of Environmental Toxicology and Chemistry (SETAC) (1993): Guidelines for Life Cycle Assessment: A 'Code of Practice'. Edition 1. From the SETAC Workshop held at Sesimbra, Portugal, 31 March – 3 April 1993. Brussels, Belgium, and Pensacola, Florida, USA, August 1993
[9] O'Brian M, Doig A, Clift R (1996): Social and Environmental Life Cycle Assessment (SELCA). Int J LCA 1, 231–237
[10] Dreyer LC, Hauschild M, Schierbeck J (2006): A Framework for Life Cycle Impact Assessment. Int J LCA 11, 88–97
[11] Labuschagne C, Brent AC (2006): Social Indicators for Sustainable Project and Technology Life Cycle Management in the Process Industry. Int J LCA 11, 3–15
[12] Weidema BP (2006): The Integration of Economic and Social Aspects in Life Cycle Impact Assessment. Int J LCA 11, Special Issue 1, 89–96
[13] Norris GA (2006): Social Impacts in Product Life Cycles. Towards Life Cycle Attribute Assessment. Int J LCA 11, Special Issue 1, 97–104
[14] Hunkeler D (2006): Societal LCA Methodology and Case Study. Int J LCA 11, 371–382
[15] Saling P, Gensch C-O, Kreisel G, Kralisch D, Diehlmann A, Preuße D, Meurer M, Kölsch D, Schmidt I (2007): Entwicklung der Nachhaltigkeitsbewertung SEEbalance® – im BMBF-Projekt 'Nachhaltige Aromatenchemie'. Karlsruher Schriften zur Geographie und Geoökologie
[16] Saling P, Kicherer A, Dittrich-Krämer B, Wittlinger R, Zombik W, Schmidt I, Schrott W, Schmidt S (2002): Eco-efficiency Analysis by BASF: The method. Int J LCA 7, 203–218
[17] Landsiedel R, Saling P (2002): Assessment of Toxicological Risks for Life Cycle Assessment and Eco-efficiency Analysis. Int J LCA 7, 261–268
[18] Kicherer A, Schaltegger S, Tschochohei H, Ferreira Pozo B (2007): Eco-Efficiency. Combining Life Cycle Assessment and Life Cycle Costs via Normalization. Int J LCA 12, 537–543
[19] University of Stuttgart LBP, Dept. Life Cycle Engineering: Social Aspects in Life Cycle Assessments (Life Cycle Working Environment – LCWE). Information leaflet (undated)
[20] Grießhammer R, Benoît C, Dreyer LC, Flysjö A, Manhart A, Mazijn B, Méthot A, Weidema BP (2006): Feasibility Study: Integration of Social Aspects into LCA. Discussion paper from UNEP/SETAC Task Force Integration of Social Aspects in LCA, Freiburg
[21] Finkbeiner M (2007): Nachhaltigkeitsbewertung von Produkten und Prozessen – Vom Leitbild zur Umsetzung. Presentation given at the 12. Produktionstechnisches Kolloquium PTK, 11. and 12.10.2007, Berlin
[22] Kloepffer W (2006): The Role of SETAC in the Development of LCA. Int J LCA 11, Special issue 1, 116–122
[23] Rikhardsson P, Bennett M, Bouma J, Schaltegger S (eds) (2005): Implementing Environmental Management Accounting: Status and Challenges. Springer Kluwer
[24] Kloepffer W, Renner I (accepted for publication (2007)): Life-Cycle Based Sustainability Assessment of Products. In: Schaltegger S (ed): Environmental Management Accounting for Cleaner Production (in print)
[25] Remmen A, Jensen AA, Frydendal J (2007): The Triple Bottom Line – the Business Case of Sustainability. In: Life Cycle Management. A Business Guide to Sustainability. UNEP/SETAC Life Cycle Initiative. ISBN 978-92-807-2772-2. UNEP 2007, 10–11
[26] Barthel L-P, Held M (2007): Social LCA – Analogies and Differences to Environmental LCA. Platform presentation at the 3rd International Conference on Life Cycle Management Zurich, 27–29 August 2007
[27] Manhart A, Grießhammer R (2007): Social Impacts of the Production of Notebooks. Platform presentation at the 3rd International Conference on Life Cycle Management Zurich, 27–29 August 2007
[28] Pesonen H-L (2007): Sustainability SWOTS – New Method for Summarizing Product Sustainability Information for Business Decision Making. Platform presentation at the 3rd International Conference on Life Cycle Management Zurich, 27–29 August 2007
[29] Benoît C, Revéret J-P (2007): Developing a Methodology for Social Life Cycle Assessment: The North American Tomato's CSR. Platform presentation at the 3rd International Conference on Life Cycle Management Zurich, 27–29 August 2007
[30] Jørgensen A, Le Bocq A, Nazarkina L, Hauschild MZ (2008): Methodologies for Social Life Cycle Assessment. Int J LCA 13 (2) 96–103
[31] Udo de Haes HA (2006): How to approach land use in LCIA or, how to avoid the Cinderella effect? Comments on 'Key Elements in a Framework for Land Use Impact Assessment Within LCA' (see [32]). Int J LCA 11, 219–221
[32] Milà i Canals L, Bauer C, Depestele J, Dubreuil A, Freiermuth Knuchel R, Gaillard G, Michelsen O, Mueller-Wenk R, Rydgren B (2007): Key Elements in a Framework for Land Use Impact Assessment Within LCA. Int J LCA 12, 5–15
[33] Bellekom S, Potting J, Benders R (2006): Feasibility of Applying Site-dependent Impact Assessment of Acidification in LCA. Int J LCA 11, 417–424
[34] Kloepffer W (1996): Reductionism versus Expansionism in LCA. Int J LCA 1, 61
[35] Kloepffer W, Renner I (2007): Lebenszyklusbasierte Nachhaltigkeitsbewertung von Produkten. Technikfolgenabschätzung – Theorie und Praxis (TATuP) 16, 32–38
[36] Huppes G (2007): Why we Need Better Eco-Efficiency Analysis. From Technological Optimism to Realism. Technikfolgenabschätzung – Theorie und Praxis (TATuP) 16, 38–45
[37] Wrisberg N, Udo de Haes HA, Triebswetter U, Eder P, Clift R (eds) (2002): Analytical Tools for Environmental Design and Management in a Systems Perspective. Kluwer Academics Publ., Dordrecht (NL)
[38] Elkington J (1997): Cannibals with Forks: The Triple Bottom Line of 21st Century Business. Capstone Publ, Oxford
[39] Rebitzer G (2007): Integrating Life Cycle Thinking into the Business Process of a Multinational Company. LCM2007, Zurich, August 27–29, 2007

Received: October 20th, 2007
Accepted: February 12th, 2008
OnlineFirst: February 13th, 2008

Comments by Helias A. Udo de Haes *

The Scientific Basis for SLCA

Helias A. Udo de Haes

Chairman of the Timber Procurement Assessment Committee of the Netherlands

In his article, Walter Klöpffer argues in favour of a triple-P approach for life cycle assessment. I fully endorse his aim, people-planet-profit is a sound basis for decision making. But the question is whether life cycle assessment is a good vector for that. In an earlier publication, cited by Klöpffer, I challenged the view that all kinds of impacts should be squeezed, with high ingenuity, into environmental LCA. Problems particularly include a quantitative relationship of the indicator to the functional unit, or high variation of the indicator at a local level of scale. Biodiversity is an example in case. This in contrast to land use as surface requirement, which can be smoothly included. Other problematic examples include life support functions such as the water household and soil erosion.

To my opinion, SLCA meets the same problem. I argue that up to now no indicator has been identified which can technically be included and meaningfully used in LCA. This in contrast to Walter Klöpffer's view that we have to choose between many possible social indicators. Right, the author carefully adds "most of them qualitative", but this means that at least some of them can be dealt with quantitatively. And his final message is quite positive: "(...) SLCA will provide the much needed tool (...)". I am not so sure about that. Also Greg Norris realised this problem. He came with the idea of Life Cycle Attribute Analysis. In this paper, that is incorrectly interpreted as example of an SLCA method, Norris put this idea forward just because potentially important social indicators do *not* fit in the structure of LCA. An example concerns the percentage of certified wood, when using wood as resource. A percentage is a fixed metric, independent from the size of the functional unit and not linearly related to it. Likewise child labour cannot easily be translated into LCA terms. I am therefore highly in favour of Norris' idea, but regard this as something complementary to formal LCA.

There is just one indicator which seems to be an exception, and that is the number of working hours per functional unit. Rightly Hunkeler elaborates this indicator which just has all characteristics for quantitative analysis inside LCA. This is also exemplified in Klöpffer's article. But here another problem emerges, namely that this indicator cannot unambiguously be interpreted. It is both good and bad. On the one hand, a high number of working hours indicates high employment per functional unit, implying high social value. On the other hand it indicates obsolete technology and therefore low competitiveness on the market. Hunkeler recognises this problem and therefore suggests to differentiate between high and low income hours. This is comparable to the struggle in environmental LCA with classes of high and low biodiversity. It thus may well be possible to find technical solutions, but to my opinion it essentially does not fit and I doubt that it will work in practice. A more fruitful and effective alley is, to my opinion, the use of other tools for conveying the urgent social messages as they concern the social criteria used for Fair Trade products.

I therefore argue against "marketing the fur before the bear has been shot", as Walter Klöpffer, to my opinion, is doing in his paper. Of course, we should continue the quest for feasible and meaningful social indicators for SLCA. But I make a plea for really comparing this with tools complementary to the LCA family, which, to my opinion, can much better fulfil the purpose at hand.

* Helias A. Udo de Haes was one of the referees for this article and prepared to directly discuss the crucial questions with the author. It was his concern to publicly present his opinion on this subject matter for the purpose of motivating the LCA community to join the discussion.

Int J LCA 11 (Special 1) 89–96 (2006)

The Integration of Economic and Social Aspects in Life Cycle Impact Assessment

Bo P. Weidema

2.-0 LCA consultants, Copenhagen, Denmark (bow@lca-net.com)

DOI: http://dx.doi.org/10.1065/lca2006.04.016

Abstract

Goal, Scope and Background. Although both cost-benefit analysis (CBA) and life cycle assessment (LCA) have developed from engineering practice, and have the same objective of a holistic ex-ante assessment of human activities, the techniques have until recently developed in relative isolation. This has resulted in a situation where much can be gained from an integration of the strong aspects of each technique. Such integration is now being prompted by the more widespread use of both CBA and LCA on the global arena, where also the issues of social responsibility are now in focus. Increasing availability of data on both biophysical and social impacts now allow the development of a truly holistic, quantitative environmental assessment technique that integrates economic, biophysical and social impact pathways in a structured and consistent way. The concept of impact pathways, linking biophysical and economic inventory results via midpoint impact indicators to final damage indicators, is well described in the LCA and CBA literature. Therefore, this paper places specific emphasis on how social aspects can be integrated in LCA.

Methods and Results. With a starting point in the conceptual structure and approach of life cycle impact assessment (LCIA), as developed by Helias Udo de Haes and the SETAC/UNEP Life Cycle Initiative, the paper identifies six damage categories under the general heading of human life and well-being. The paper proposes a comprehensive set of indicators, with units of measurement, and a first estimate of global normalisation values, based on incidence or prevalence data from statistical sources and severity scores from health state analogues. Examples are provided of impact chains linking social inventory indicators to impacts on both human well-being and productivity.

Recommendations and Perspectives. It is suggested that human well-being measured in QALYs (Quality Adjusted Life Years) may provide an attractive single-score alternative to direct monetarisation.

Keywords: Areas of protection; child labour; cost-benefit analysis (CBA); human well-being; impact pathways; monetarisation; quality adjusted life years (QALY); single score; sustainability; well-being gap